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COMPUTER TECHNOLOGY

Expanding the Dental Practice

CENTER FOR
DENTAL INFORMATION

COMPUTER TECHNOLOGY EXPANDING THE DENTAL PRACTICE

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INTRODUCTION

Although computers were rare in dental offices only a decade ago, they have since become increasingly common. Initially used primarily for office management, computers are more frequently being incorporated into the treatment areas as well. Computers and computer-based functions are powerful adjuncts to the practice of dentistry, and their use is changing the way dentistry is practiced.

The earliest computer applications in dental office management were a logical extension of existing business and database* software* applications. Now the computer is a well-established necessity for conducting the business functions of a dental practice, and it is only natural that this technology also should be applied to clinical functions.

Computers have the ability to perform complex calculations, manage and organize large amounts of information and produce and manipulate images. These functions allow computers to simplify practice management procedures and offer new options for the imaging, design and fabrication of dental restorations, as well as for diagnosis and treatment planning. As national and international databases are established, quality assurance will become an important contribution to dental practice efficacy and improved patient care.

This monograph explores both established and emerging computer applications and provides an overview of the ways computers are revolutionizing dentistry. These changes will continue for many years, and in the near future, computers will be acknowledged as a basic necessity for a modern dental practice.

"The computer offers a knowledge and communication resource that surpasses anything previously available. Its routine acceptance into the dental practice is inevitable. When metal ceramic restorations first were offered to dentistry they were problematic, and the esthetic result was often unacceptable. Failures were not infrequent, and the restoration was often denigrated. Today the metal ceramic restoration is the most widely used and accepted fixed restoration. Similarly, it will take time for the computer to be established in the dental practice as its efficacy is enhanced and its functions expanded. We have only seen a small portion of its potential put to routine use. Computer-assisted clinical care will eventually alter not only office procedures and structure, but practice philosophy as well."

Jack D. Preston, D.D.S.,
chairman, Department of Oral and Maxillofacial Imaging and Department of Continuing Education, The Don and Sybil Harrington Foundation professor of Esthetic Dentistry, University of Southern California School of Dentistry

DATABASE
Systematic, related information stored as a reference base for the computer. A patient database, for example, could include all the information normally found in a paper file, including names, addresses, phone numbers, insurance information, medical history and treatment records.

SOFTWARE
The encoded programs that are used by the computer to process data and produce the desired output. Contrast with "hardware."

CAD/CAM*

The use of computers to design and fabricate restorations is the most sophisticated and one of the most exciting dental applications of electronic science. Computer-assisted design and computer-assisted manufacture, CAD/CAM, is a technology adapted from industry, where virtually every machine shop and production line relies on this process for product design and

CAD/CAM MAY BE USED TO PRODUCE INLAYS, ONLAYS, CROWNS OR LAMINATE VENEERS.

fabrication. However, although most industrial applications use CAD/CAM to fabricate numerous replicas of a product, in dentistry each product (restoration) is designed and formed only once.

To fabricate a dental restoration, an image of the prepared tooth or die must be acquired and stored in the computer. That image is then transferred to the CAD station, where it is designed using computer imaging software and display. The design data are then used to drive a numerically controlled milling machine (CAM). Currently, CAD/CAM may be used to produce inlays, onlays, crowns or laminate veneers. In the future, it will be used for more extensive restorations.

In traditional restorative procedures, an impression is made, a stone cast is formed in the impression and a wax

THE COMPUTER PROCESSES THE ACQUIRED DATA TO DEVELOP A THREE-DIMENSIONAL IMAGE OF THE PREPARED TOOTH AND ADJACENT SURFACES.

pattern is created on the resulting die. The wax pattern is invested and cast in metal or, perhaps, a castable ceramic material. With CAD/CAM, the impression and die procedures are analogous to image acquisition, and waxing is replaced by the CAD. Just as a wax pattern may be manipulated to achieve the desired functional and esthetic form, the virtual restoration (image) may be shaped using the CAD software.

Images may be acquired either by using a special laser camera or by tracing the surface of the tooth with a microprobe linked to the computer (contact digitizing). Either way, the computer processes the acquired data to develop a three-dimensional image of the prepared tooth and adjacent surfaces. These data are points in three-dimensional space and represent a "virtual die" upon which the restoration is designed.

The development of computer equipment necessary for dental CAD/CAM has led to the formation and demise of several companies. This very complex computer application requires a substantial investment to design and produce, and intraoral imaging constraints preclude easy adaptation of industrial technology. A number of companies have dental applications under development, but only a few systems are commercially available today.

THE PROCERA® SYSTEM

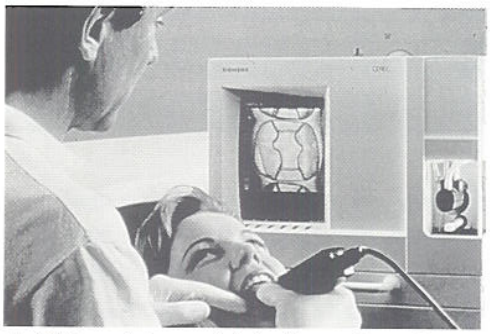
Titanium and titanium alloys have become well established as materials for endosseous implants. As a result, there has been interest in developing a restorative system using titanium as a substructure for resin or ceramic veneering. The Procera system (Nobelpharma, Goteborg, Sweden) was developed for such a purpose. The system uses a spark erosion and copy milling process to shape the titanium. Carbon electrodes shaped like the die

CAD/CAM (Computer-Assisted Design/Computer-Assisted Manufacture) The graphical design of a product and its subsequent manufacture using a numerically controlled device such as a milling machine.

are formed by copy milling, i.e., tracing the die with a pantographic device that is connected to a milling machine, much the way keys are duplicated. The electrodes are used to electromill the internal of the titanium work piece. CAD is used to design the exterior of the coping and to control the electromachining of that surface. The titanium coping may be veneered with resin or porcelain, and studies in Sweden have shown the process to produce clinically satisfactory results.

THE CEREC® SYSTEM

The CEREC system is the most widely available CAD/CAM system for fabrication of inlays, onlays and veneers. CEREC is an acronym for ceramic reconstruction. The system is self-contained and houses a laser



The CEREC system's features include the ability to make optical impressions, design restorations directly on the monitor and fabricate inlays, onlays and veneers all within a single integrated unit. (Courtesy of Pelton & Crane, a Siemens Company)

imaging probe, a monitor for viewing the image and an electric milling machine. A single image is made using the laser camera. The system is not designed to accept more than one image or to correlate multiple images. The margins of the preparation are outlined using a track ball* to move the cursor, defining both the internal and external extent of the cavity. A diamond disk then machines the fit surface of the restoration from a ceramic block. The occlusal surface is only grossly developed, and any anatomy must be carved by the dentist or when the inlay is seated on the tooth.

The system is a self-contained unit that has no design capability beyond that described. The use of a diamond wheel(s) for machining the restoration limits its use to in-office fabrication of ceramic inlays, onlays and veneers; the system is not adaptable for fabrication of crowns. Recently, Siemens introduced an improved version of the CEREC system incorporating dual-milling mechanisms, a disk and a cylinder, that provide enhanced efficiency.

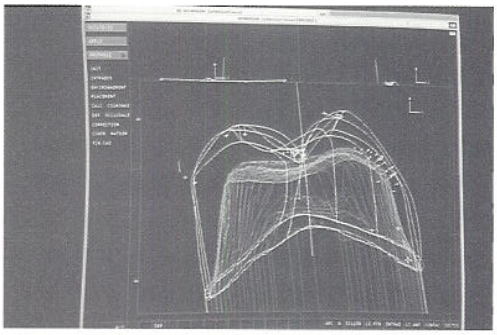
THE DURET SYSTEM

The system developed by Professor François Duret uses a laser imaging camera to acquire multiple views of the prepared tooth and correlate them into a true three-dimensional image. Currently, the system works from a cast of the prepared tooth rather than directly in the mouth. Multiple images are acquired, correlated by the software and displayed so the user might define the margin and other landmarks. The occlusal relationships are established by imaging an interarch record placed over the die. After the necessary information has been input, a three-dimensional image is formed and passed to a CAD station where the restoration is designed.

Although the system may be used in an automatic mode, it is best used as an interactive system. All aspects of the design are under the operator's control, from die "spacing" to controlling the occlusal surface. The system uses a "library" of tooth forms from which the restoration may be customized. The operator may selectively expand the

TRACK BALL
A stationary input device, with a movable ball, that relays positioning information to the computer similar to a "mouse on its back." (See "mouse".)

"die" as desired to provide cement space, alter the cusp height and ridge and groove direction, as well as modify all external contours as desired.



Once the image of the prepared tooth is captured, the computer can design the restoration, although the operator can make modifications to customize the final design for an individual patient.
(Courtesy of Technodent Systems, Inc.)

When the desired form has been achieved, the information is sent to the CAM unit. The system uses a 5 axis milling machine with diamond and carbide milling tools. All tool manipulation is automatic, and the finished piece is completed, requiring only minor modifications to remove the areas where it was retained in the original block.

MATERIALS FOR CAD/CAM

Research is presently being conducted on materials especially developed for CAD/CAM rather than using those adapted from other technologies. All of

CAD/CAM...OFFERS THE PREFABRICATION OF MATERIALS WITHOUT THE CURRENT LIMITATIONS OF CONVENTIONAL DENTAL LABORATORY PROCESSING.

the processing techniques in dentistry have required reformation (melting and casting, or firing) of the initial material. CAD/CAM changes this perspective and offers the prefabrication of materials without the current limitations of conventional dental laboratory processing. A distinct limitation of CAD/CAM is the paucity of materials available for fabricating esthetic units. There is much opportunity for innovative design and development.

THE FUTURE FOR CAD/CAM

The amount of research and development interest throughout the world indicates that CAD/CAM will have a definite place in routine dentistry. The Japanese have a number of fascinating projects, and marketable products are expected soon. CAD/CAM technology can be applied to both intraoral and indirect laboratory use; it will find widespread acceptance when intraoral appli-

ALTHOUGH DENTAL CAD/CAM TECHNOLOGY IS IN ITS INFANCY, IT HOLDS THE POTENTIAL FOR MANY MORE APPLICATIONS THAN ARE READILY APPARENT.

cations are made practical and cost effective. The potential for time and labor savings, including elimination of the provisional restoration and a reduced number of patient visits, provides economic incentive to the quest for improved and affordable systems.

Although dental CAD/CAM technology is in its infancy, it holds the potential for many more applications than are readily apparent. To optimize its potential, CAD/CAM systems will eventually be integrated with other computer-based dental applications such as mandibular movement recording, expert systems* and decision support, digital radiography and video imaging.

EXPERT SYSTEM
Computer program that draws on a broad base of preassembled, highly specialized knowledge. In medical and dental applications, an expert system may be designed to help the user solve complex problems, such as diagnosis or treatment planning.